

# TREES AND THEIR IMPACT ON ELECTRIC RELIABILITY DURING AND FOLLOWING TROPICAL STORM ISABEL

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## ABSTRACT

With Isabel, rainfall was less than expected and wind speeds were below those normally associated with significant tree failure. Despite this situation, tree failures and associated utility outages were massive and five days after the storm more than 2 million people in the Mid-Atlantic region remained without electricity. The Maryland Public Service Commission's (PSC) inquiry into electrical service interruptions related to the storm considered what impact, if any, certain tree protection laws administered by the Department of Natural Resources (DNR) had on utility outages.

The storm was an act of God and the impacts were not accounted for by existing utility vegetation management practices. A preponderance of dead or damaged roadside trees in the Baltimore-Washington corridor coincided with the area having the majority of utility outages. The DNR laws regulating tree care require adherence to the industry-consensus standards for tree care operations. Adherence to proper tree care practice has been demonstrated to improve electric reliability. A new treatment paradigm—one that addresses trees outside of the traditional treatment envelope and focuses on amelioration of mechanical defects and storm forces on tree crowns using tree pruning, removal, and replacement—may reduce the severity of tree-related utility outages during storms.

## INTRODUCTION

Isabel was declared a hurricane on 7 September 2003. By the time it reached landfall

on 18 September 2003, it had been downgraded to a tropical storm [1]. Upon arrival in Maryland, the storm had maximum sustained winds of approximately 45 mph (72 km·hr<sup>-1</sup>) and peak gusts of approximately 58 mph (93 km·hr<sup>-1</sup>) [2, 3]. Rainfall was less than expected and winds were at speeds below those normally associated with significant tree failure. Despite this situation, tree failures and utility outages were widespread; five days after the storm, more than 2 million people in the Mid-Atlantic region remained without electricity [4], primarily in the Baltimore-Washington corridor.

The Maryland Public Service Commission (PSC) regulates public utilities per the Annotated Code of Maryland Public Utilities Article. The Maryland Department of Natural Resources (DNR) administers numerous laws regulating the treatment of trees under this same article. Since trees can fail and cause electric utility outages, some entities have sought certain exemptions from, or repeal of, certain tree protection laws administered by DNR following major storms.

PSC Case Number 8826, "Investigation into the Preparedness of Maryland Utilities for Responding to Major Outages," was initiated following Tropical Storm Floyd in 1999. In that case, the PSC directed "electric utilities and telephone companies, PSC Staff, the Office of People's Counsel, and other interested parties to work with the Maryland Department of Natural Resources (DNR) to develop recommended modifications to the State's policies and regulations to improve utility tree trimming and maintenance programs within utility rights-of-way, and to evaluate the need for appropriate legislation or regulations with regard to tree trimming on private property [5]."

The former clause of the PSC's charge (regarding utility tree trimming and maintenance programs within utility rights-of-way) developed into a discussion of the validity and applicability of the Maryland Roadside Tree law; the latter clause (regarding tree trimming on private property) led to a similar discussion regarding the Maryland Licensed Tree Expert law.

*Natural Resources: Title 5. Forests and Parks: Subtitle 4. Trees and Forest Nurseries: Part I. Roadside Trees* §§ 5-401 – §§ 5-411 was passed in 1914. It was developed to protect our roadside trees by ensuring their proper care and protection and to ensure their compatibility with an efficient and dependable public utility system. It provides that any treatment of a roadside tree (a plant that has a woody stem or trunk that grows all, or in part, within the right-of-way of a public road) be subject to approval and regulation by the DNR [6]. Parties wishing to treat (prune, remove, etc.) roadside trees must obtain a permit to do so and must perform the treatments according to regulations promulgated by the department. Because many electric utility distribution lines run along public roads above or adjacent to roadside trees, electric utilities are the primary user group of the permitting process.

*Natural Resources: Title 5. Forests and Parks: Subtitle 4. Trees and Forest Nurseries: Part III. Tree Experts* §§ 5-415 – §§ 5-423 was enacted in 1945. It provides criminal penalties for those that operate or advertise as a tree expert without a license issued by the department, and also allows the department to permanently revoke or temporarily suspend the license of any licensed tree expert who is found guilty of any fraud or deceit in obtaining the license or is guilty of negligence or wrongful conduct in the practice of tree culture or care [7]. Contractors providing tree care services for utilities are subject to this law; multiple contractors for one electric utility have been subject to sanction by the department under it.

The PSC's order 77132 regarding Case 8826 concluded that certain non-regulatory steps identified by the working group "will enhance the reliability of circuits along the public rights-of-way yet leave Maryland with healthy and properly

pruned trees without revising any existing laws or regulations [5]." Primary among these was formation of the Maryland Electric Reliability Tree Trimming (MERTT) Council, made up of the parties named to the initial working group created during the case, which has met quarterly since initiation of that order to coordinate issues relating to trees and electric reliability.

PSC Case 8977, "In the Matter of the Electric Service Interruptions due to Hurricane/Tropical Storm Isabel and the Thunderstorms of August 26–28, 2003," brought another review of whether DNR's administration of these laws caused a significant hindrance to electric reliability, utility preparedness, and post-storm response.

## MATERIALS AND METHODS

Documents on file with the Public Service Commission relative to the noted storms were reviewed [5, 8]. Data collected by the Maryland Department of Agriculture under the USDA Forest Service Urban Forest Health Monitoring – Stage 2: State-wide Street Tree Assessments protocol [9] were analyzed for comparisons of the number and percentage of total trees, dead trees, damaged trees, and trees with overhead wire conflicts in various areas of the state. The data are scheduled for publication in mid- to late 2005. The USDA Forest Service had stratified the data by aligning county data into regions. To better align the data with DNR's regions and Maryland utility territories, DNR requested that the Forest Service perform additional analysis with the counties aligned by region as shown in Table 1. The Forest Service performed this analysis.

Weather data for Baltimore and Washington on the day Isabel reached Maryland were reviewed and related to information associated with other storms [1, 2, 3, 10, 11, 12].

Published literature and industry standards for tree care were also reviewed for applicable information regarding the effect of storms and tree treatment methods on tree structure and health as well as electric reliability [9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21].

**Table 1.** Grouping of jurisdictions.

Baltimore-Washington	Eastern	Western
Anne Arundel	Caroline	Allegany
Baltimore	Cecil	Frederick
Baltimore City	Dorchester	Garrett
Carroll	Kent	Washington
Harford	Queen Anne	
Howard	Somerset	
Montgomery	Talbot	
Prince George's	Wicomico	
	Worcester	

## RESULTS AND DISCUSSION

### Environmental conditions

Isabel hit the Baltimore-Washington area with maximum sustained winds equaling F0 on the Fujita tornado scale and 8 on the Beaufort scale. The Fujita scale lists no tree effects associated with winds of this speed. The Beaufort scale associates twigs breaking with winds of this speed. According to both scales, shallow-rooted trees are pushed over, and trees are broken or uprooted when wind speeds reach 55–63 mph (89–101 km·hr<sup>-1</sup>) [13].

Trees adapt mechanically to brace against prevailing winds [14], which in this area normally travel west to east. The counterclockwise motion of the storm brought winds from the opposite direction. Maximum sustained winds and peak gusts recorded at Washington National and BWI airports during the storm came from the east [2, 3].

Prior to the storm, soils around the state were already at or near saturation due to above-average rainfall for most of the year [10]. The USGS average streamflow index for Maryland was above average and increased consistently from October 2002 through the date of the event, resulting in the highest September groundwater levels in 40 years, high streamflow levels, and flooding [11].

According to the PSC Office of Staff Counsel [8], the majority of tree failures during Isabel came

as uprooted trees. This situation contrasts with the devastating tornado (Fujita category F4) that hit La Plata, Maryland in April 2002, where the majority of tree damage was to crowns (defoliation, broken branches, loss of apical dominance) rather than to roots or stems (uprooting, broken boles, cracks and seams) [12]. In contrast to Isabel, the La Plata storm was preceded by approximately 8 months of below-average soil moisture.

### Roadside trees

The collected data were post-stratified as shown in Table 1. Table 2 shows the results. A preponderance of dead or damaged roadside trees in the Baltimore-Washington corridor coincided with the area of the majority of utility outages [8]. Tree cover in road rights-of-way in the Baltimore-Washington corridor is 13%. This number is more than twice as high as on the Eastern Shore (6%) and more than 6 times as much as in western Maryland (2%). More than three times as many roadside trees  $\geq 2.54$  cm ( $\geq 1$  in) in diameter per road mile occur in the Baltimore-Washington area than in other parts of the state. When counting only trees 25.4 cm ( $\geq 10$  in) in diameter, the ratio of roadside trees Baltimore-Washington compared to other parts of the state changes to 2:1 in comparison with the Eastern Shore and 5:1 in comparison with western Maryland.

Conflicts between roadside trees and overhead wires are much more prevalent in Baltimore-Washington and on the Eastern Shore. The number of roadside trees per mile in conflict with overhead wires is similar in Baltimore-Washington and the Eastern Shore, but the percentage of miles of right-of-way in conflict is much lower in the Baltimore-Washington area since many more road miles occur there compared to the shore.

The average number of dead or damaged roadside trees per road mile is significantly higher in Baltimore-Washington than in the rest of the state. The percentages of roadside trees that are dead, damaged, severely damaged, and/or have damage to the root or trunk area are also much higher in Baltimore-Washington than in the rest of the state. Structurally compromised trees or tree

**Table 2.** Roadside tree data by region.

Size	Item	Baltimore-Washington	Eastern	Western
	% tree cover in right-of-way	13.0	6.0	2.0
	Wire conflicts per mile	8.2	8.2	0.0
	% right-of-way w/ tree/wire conflict	9.0	16.4	0.0
	Sidewalk conflicts per mile	7.5	2.7	14.6
	Plantable spaces per mile	24	41	32
± 1"	Mean trees per mile	50.7	16.6	13.0
± 1"	Mean dead trees per mile	0.8	0	0
± 1"	Mean damaged tree per mile	6.8	0.7	0
± 5"	Mean trees per mile	39.1	13.9	13.0
± 5"	% dead	1.5	0	0
± 5"	% damaged	13.2	4	0
± 5"	% no damage	52.5	95.2	87.5
± 5"	% damaged: conks	7.9	4.8	0
± 5"	% damaged: open wounds	12.6	0	12.5
± 5"	% damaged: other lower bole	12.6	0	0
± 10"	Mean trees per mile	24.5	12.6	4.9

parts are more likely to fail, particularly during storms [16].

### **Treatment Standards Specified in the Roadside Tree law and Licensed Tree Expert Law**

The noted tree laws require, through Incorporation by Reference, by direct inclusion, or by paraphrase, adherence to the American National Standards Institute (ANSI) standards for tree care operations [22]. The American National Standards Institute (ANSI) is a private, non-profit organization (501(c)3) that administers and coordinates the U.S. voluntary standardization and conformity assessment system. The ANSI standards

for tree care operations are industry-consensus standards [23].

Federal government agencies use voluntary standards such as ANSI standards for regulatory purposes when appropriate [24]. Many state and local governments also use ANSI to assess standards of goods or services, as is the case regarding the noted laws.

### **Effects of Treatment Methods on Reliability**

Because most utilities, due to monetary considerations, easement limitations, and risk management best management practices (BMPs), focus management on the most likely risk scenarios (crown growth into the lines, crown failure onto lines), the impacts from Isabel were outside of their risk management schemes, although they were similar to those of Tropical Storm Floyd. Following analysis of utility treatment methods and storm impacts related to Isabel, the PSC Office of Staff Counsel reported that it “. . . does not recommend any changes to utility tree-trimming practices [8],” and the PSC concluded that “Generally, the utilities commented that tree-trimming practices would not have prevented the outages. . . . Even the most aggressive trimming methods can not avoid damage caused by the collapse of an entire tree [5].”

It has been demonstrated that implementation of certain practices during utility tree trimming can result in reliable service and quality tree care. Directional pruning of mature trees under utility lines in a manner that correlates to ANSI standards has been found cost effective and increases electric reliability [16]. Several sources [17, 18, 19] suggest that topping—a technique not endorsed by ANSI—is unethical and malpractice by practitioners. “Topping or heading . . . is cutting branches to stubs or laterals (internodal cuts) that are not large enough to assume the terminal role [18].”

During a storm, generated forces are centered at a point that is approximately 40% of the living-crown height below the crown top in open-grown trees. The effect of such forces on tree crowns can be ameliorated in three ways: crown raising (removing lower limbs); crown reduction (reducing the uppermost and side branches to sufficient lateral

branches closer to the main stem); and thinning (reducing the density of branches within the crown) [20]. Such pruning should be performed according to ANSI standards.

Most utilities' tree-trimming programs are based on clearing all vegetation within a specified distance of the wires or clearance envelope, based on the voltage carried in the lines, with the clearance distance superseding considerations of ANSI [8]. In both Floyd and Isabel, however, widespread utility outages were caused by trees or tree parts failing into the lines from outside of the customary treatment envelope [5, 8]. A new treatment paradigm that addresses trees outside of the traditional treatment envelope and focuses on amelioration of mechanical defects and storm forces on tree crowns would likely reduce the severity of tree-related utility outages during storms such as Isabel. Simpson and Van Bossuyt [21] demonstrated that identification and treatment of trees with structural defects adjacent to three-phase portions of distribution circuits resulted in 4% of trees in the utility corridor being treated with a resulting 20–30% increase in reliability. As many defective trees could be outside of easements held by a Maryland utility, however, some form of mitigation program (provision of full or cost-shared tree replacement) would likely be necessary. Some Maryland utilities currently have such programs in place to induce property owner compliance with utility vegetation management objectives. Simpson and Van Bossuyt also reported that mitigation was a component of their successful program [21]. Mitigation programs provide the additional benefit of populating a space with utility-compatible vegetation, reducing the likelihood of colonization of the area by undesirable vegetation.

In its order related to the Isabel investigation, the PSC “ordered that the Commission’s Engineering Division Staff and the electric utilities work through the Maryland Electric Reliability Tree Trimming Council to develop a detailed recommendation for specific actions that utilities can take to best manage privately owned trees near utility rights-of-way, and that the utilities shall commence public education efforts in conjunction

with local governments within their respective service areas to increase awareness of the potential risk to their power supply that property owners incur in planting trees too close to power lines [5].” The DNR will submit this report to the MERTT Council as a contribution towards development of recommendations as charged by the PSC.

## ACKNOWLEDGMENTS

The author would like to thank: the USDA Forest Service and the Maryland Department of Agriculture for collection and provision of the Urban Forest Health Monitoring – Stage 2: State-wide Street Tree Assessments data for Maryland; Anne Buckelew Cumming, Urban Forester, USDA Forest Service, for providing the revised statistical data analysis based on the requested reassignment of counties to various regions of the state; and members of the MERTT Council (Maryland Public Service Commission, Maryland Department of Natural Resources [Forest Service, Resource Assessment Service], Allegany Power, BGE, Choptank Electric, Conectiv, Pepco, and SMECO for their ongoing partnership in enhancing the compatibility of our green and grey infrastructures.

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